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UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)*(Only for new nonprovisional applications under 37 CFR 1.53(b))*Docket No.
05516/084001

Total Pages in this Submission

TO THE ASSISTANT COMMISSIONER FOR PATENTSBox Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

**STRUCTURE FOR POLYCRYSTALLINE DIAMOND INSERT DRILL
BIT BODY AND METHOD FOR MAKING**

and invented by:

Graham MENSA-WILMOT, Tommy G. RAY, and Youhe ZHANGIf a **CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

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Enclosed are:

Application Elements

1. ☐ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 13 pages and including the following:
 - a. ☒ Descriptive Title of the Invention
 - b. ☐ Cross References to Related Applications *(if applicable)*
 - c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
 - d. ☐ Reference to Microfiche Appendix *(if applicable)*
 - e. ☒ Background of the Invention
 - f. ☒ Brief Summary of the Invention
 - g. ☒ Brief Description of the Drawings *(if drawings filed)*
 - h. ☒ Detailed Description
 - i. ☒ Claim(s) as Classified Below
 - j. ☒ Abstract of the Disclosure



22511

PATENT TRADEMARK OFFICE

UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

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Application Elements (Continued)

3. ☒ Drawing(s) (when necessary as prescribed by 35 USC 113)
- a. ☐ Formal Number of Sheets _____
- b. ☒ Informal Number of Sheets 3
4. ☒ Oath or Declaration
- a. ☐ Newly executed (original or copy) ☒ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional application only)
- c. ☒ With Power of Attorney ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application,
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (usable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer Program in Microfiche (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all must be included)
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy (identical to computer copy)
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(B) Statement (when there is an assignee)
10. ☐ English Translation Document (if applicable)
11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☒ Certificate of Mailing
- ☐ First Class ☒ Express Mail (Specify Label No.): EL656800825US

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Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. ☐ Additional Enclosures *(please identify below):*

Request That Application Not Be Published Pursuant To 35 U.S.C. 122(b)(2)

17. ☐ Pursuant to 35 U.S.C. 122(b)(2), Applicant hereby requests that this patent application not be published pursuant to 35 U.S.C. 122(b)(1). Applicant hereby certifies that the invention disclosed in this application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication of applications 18 months after filing of the application.

Warning

An applicant who makes a request not to publish, but who subsequently files in a foreign country or under a multilateral international agreement specified in 35 U.S.C. 122(b)(2)(B)(i), must notify the Director of such filing not later than 45 days after the date of the filing of such foreign or international application. A failure of the applicant to provide such notice within the prescribed period shall result in the application being regarded as abandoned, unless it is shown to the satisfaction of the Director that the delay in submitting the notice was unintentional.

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Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	14	- 20 =	0	x \$18.00	\$0.00
Indep. Claims	5	- 3 =	2	x \$80.00	\$160.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$710.00
OTHER FEE (specify purpose)					\$0.00
TOTAL FILING FEE					\$870.00

*** FILING FEES DEFERRED ***

- ☐ A check in the amount of _____ to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **50-0591** as described below. A duplicate copy of this sheet is enclosed.
- ☐ Charge the amount of _____ as filing fee.
- ☒ Credit any overpayment.
- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

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APPLICATION
FOR
UNITED STATES LETTERS PATENT

**TITLE: STRUCTURE FOR POLYCRYSTALLINE
DIAMOND INSERT DRILL BIT BODY AND
METHOD FOR MAKING**

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TOMMY G. RAY
YOUHE ZHANG**

EXPRESS MAIL Mailing Label Number: EL656800825US

Date of Deposit: October 26, 2000



22511

PATENT TRADEMARK OFFICE

STRUCTURE FOR POLYCRYSTALLINE DIAMOND INSERT DRILL BIT BODY AND METHOD FOR MAKING

FIELD OF THE INVENTION

The invention is related to the field of fixed cutter bits used to drill wellbores through earth formations. More specifically, the invention is related to structures for, and methods for making, alloy bodies for polycrystalline diamond compact cutter drill bits.

BACKGROUND OF THE INVENTION

Fixed cutter drill bits known in the art include polycrystalline diamond compact (PDC) bits. The typical PDC bit includes a bit body which is made from powdered tungsten carbide infiltrated with a binder alloy within a suitable mold form. The particular materials used to form PDC bit bodies are selected to provide adequate toughness, while providing good resistance to abrasive and erosive wear. The cutting elements used on these bits are typically formed from a cylindrical tungsten carbide "blank" or substrate. A diamond "table" made from various forms of natural and/or synthetic diamond is affixed to the substrate. The substrate is then generally brazed or otherwise bonded to the bit body in a selected position on the surface of the body.

The materials used to form PDC bit bodies, in order to be resistant to wear, are very hard and are therefore difficult to machine. Therefore, the selected positions at which the PDC cutting elements are to be affixed to the bit body are typically formed substantially to their final shape during the bit body molding process. A common practice in molding PDC bit bodies is to include in the mold at each of the to-be-formed cutter mounting positions, a shaping element called a "displacement". A displacement is generally a small cylinder made from graphite or other heat resistant material which is affixed to the inside of the mold at each of

the places where a PDC cutter is to be located on the finished drill bit. The displacement forms the shape of the cutter mounting positions during the bit body molding process. See, for example, U.S. patent no. 5,662,183 issued to Fang for a description of the infiltration molding process using displacements.

5 PDC bits known in the art have been subject to fracture failure of the diamond table, and/or separation of the diamond table from the substrate during drilling operations. One reason for such failures is compressive contact between the exterior of the diamond table and the proximate surface of the bit body under drilling loading conditions. One solution to this problem known in the art is to
10 mount the cutting elements so that substantially all of the thickness of the diamond table is projected outward past the surface of the bit body. While this solution does reduce the incidence of diamond table failure, having the diamond tables extend outwardly past the bit body can cause erratic or turbulent flow of drilling fluid past the cutting elements on the bit. This turbulent flow has been known to
15 cause the cutter mounting to erode, and to cause the bonding between the cutters and the bit body to fail, among other deficiencies in this type of PDC bit configuration. It is preferable to have the PDC cutters mounted so that they are substantially flush with the outer surface of the mounting position on the bit body.

What is needed is a structure for a PDC bit body which reduces diamond
20 table failure, while retaining the benefits of flush mounting of the cutters on the bit body.

SUMMARY OF THE INVENTION

One aspect of the invention is a method for forming a drill bit body which comprises infiltrating powdered tungsten carbide with a binder alloy in a mold.
25 The mold has therein at least one displacement adapted to form a mounting pad for a cutting element. The displacement comprises a substantially cylindrical body

having a diameter selected to substantially conform to a radius of the cutting element and a projection adapted to form a relief groove under a position of a diamond table forming part of the cutting element when the cutting element is mounted on the pad. The width of the relief groove is selected so that the relief
5 groove extends back from an outer surface of the bit body at least about 40 percent of that portion of a thickness of the diamond table which does not extend past the outer surface.

Another aspect of the invention is a drill bit body comprising a main body having at least one blade formed therein, and at least one cutting element
10 mounting pad formed on the at least one blade. The mounting pad is adapted to receive therein a substrate of a cutting element. The mounting pad has a relief groove therein under a position of a diamond table in the cutting element when the cutting element is mounted on the pad. The width of the relief groove is selected
15 so that the relief groove extends back from an outer surface of the blade at least about 40 percent of that portion of a thickness of the diamond table which does not extend past the outer surface.

Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

20 Figure 1 shows a side view of one example of a displacement made according to the invention

Figure 2 shows an end view of a displacement such as shown in Figure 1.

Figure 3 shows a cross section of a drill bit body having a cutting element mounted on a pad made according to the invention.

25 Figure 4 shows an example of a PDC drill bit made according to the invention.

DETAILED DESCRIPTION

A matrix drill bit body for a fixed cutter bit according to the various embodiments of the invention can be made from powdered tungsten carbide infiltrated with a binder alloy in a suitably shaped mold or other form. See, for example, U.S. patent no. 5,662,183 issued to Fang, incorporated herein by reference. In particular, the bit body forming process described in the Fang '183 patent includes insertion of plugs, called "displacements," in locations about the bit body on which cutting elements are to be mounted to the finished bit body. The locations at which cutting elements are to be mounted are referred to for convenience herein as "mounting pads".

In a drill bit body made according to the invention, displacements are inserted into the mold during the body forming process to produce mounting pads for the cutting elements. An example of a displacement according to one aspect of the invention is shown in Figure 1. The displacement 10 in this embodiment is a substantially cylindrical body having a selected length indicated by L, a diameter indicated by D and on one end, a projection 12 having a selected width W. The length L and diameter D are selected to provide a mounting pad (not shown in Figure 1) on the finished bit body (not shown in Figure 1) having dimensions suitable to mount a selected cutting element (not shown in Figure 1). Typically the cutting element (not shown in Figure 1) affixed to the mounting pad will be a polycrystalline diamond compact insert. The projection 12 in this embodiment has a substantially cylindrical shape and extends laterally past the exterior surface 10A of the main body of the displacement 10 by about 0.025 inches (0.63 mm) in this embodiment. The displacement 10 is affixed to the mold (not shown in Figure 1) so that the mounting pad is formed to have a recess or relief groove (not shown in Figure 1) positioned under a diamond table forming part of the cutting element

affixed to the mounting pad. The position of the relief groove and diamond table will be further explained.

The example displacement is shown in an end view in Figure 2, where the shape and lateral extent of the projection 12 can be seen. In this embodiment, the projection 12 has a primary surface 12A which extends laterally from the surface (10A in Figure 1) of the displacement by about 0.025 inches (0.63 mm) and is substantially concentric with the surface (10A in Figure 1) of the displacement 10 between points A and B. Transition surfaces, formed between endpoint A and point C1, and endpoint B and point C2 on the circumference of the displacement 10, can be formed to gradually adjust the radius of the exterior surface of the projection 12 to match the radius of the main surface 10A of the displacement 10. Typically, points C1 and C2 will be spaced about 180 degrees apart, so that the relief groove formed in the mounting pad will extend about 180 degrees. Other angular spacings of points C1 and C2, and endpoints A and B will also work with the invention, however.

The displacement 10 may be made from graphite or any other suitable material used for molding of matrix bodies. Using casting or cold pressing methods can be advantageous by enabling forming the displacement 10, including the projection 12 thereon, as a single piece.

As described in the Fang '183 patent, after the displacements are inserted into selected locations in the mold, powdered tungsten carbide is inserted into the mold and is then infiltrated with a binder alloy. Typically, the bit body thus formed will include "blades", each of which includes one or more of the mounting pads formed by the displacements.

A blade portion of a bit body formed using a displacement such as shown in Figures 1 and 2, is shown in cross section in Figure 3. The blade 24 includes thereon a mounting pad 25 having the shape of the displacement (10 in Figure 1).

As previously explained, the radius of the mounting pad 25 is determined by the diameter (D in Figure 1) of the displacement. Typically, this radius is selected to match the radius of the cutting element mounted thereon. As shown in Figure 3, a relief groove 26 is formed in the mounting pad 25 by having placed the displacement (10 in Figure 1) in the mold so that the projection (12 in Figure 1) was positioned outward and downward with respect to the blade 24. Shown mounted in the pad 25 is a cutting element consisting of a diamond table 20 affixed to a substrate 22. Typically, the substrate 22 is formed from tungsten carbide or similar hard material. The diamond table 20 can be formed in any manner known in the art for making diamond cutting surfaces for fixed cutter drill bits. The cutting element is typically bonded to the blade 24 by brazing the substrate 22 to the blade 24.

In this embodiment, the diamond table 20 extends longitudinally past the surface of the blade 24 by an amount shown at E. The diamond table 22 has a thickness Z which is selected based on the diameter of the cutting element and the expected use of the particular drill bit, among other factors. In the invention, it has been determined that diamond table breakage is reduced efficiently when the width X of the relief groove 26 is selected so that the groove 26 extends back from the surface of the blade 24 at least about 40 percent of that portion (Z - E) of the thickness Z of the diamond table which does not extend past the edge of the blade 24. Expressed mathematically:

$$X / (Z - E) \geq 0.40$$

In the example shown in Figure 3, the diamond table thickness Z is about 0.110 inches (2.8 mm) and an extension E of the outer surface of the diamond table 22 past the edge of the blade 24 is about 0.040 inches (1 mm). The width X of the relief groove 25 should therefore be greater than or equal to about 0.028 inches (0.7 mm). As previously explained, the width Z of the relief groove 25 can

be selected by appropriate choice of the width (W in Figure 1) of the projection (12 in Figure 1) on the displacement.

Preferably, the relief groove 25 has a depth of about 0.025 inches (0.6 mm). As previously explained, this depth can be formed in the bit body at the position of
5 any or all of the mounting pads 24 by forming the displacement (10 in Figure 2) so that the projection (12 in Figure 2) extends past the main surface (10A in Figure 2) by about 0.025 inches (0.6 mm).

In a drill bit body made according to the invention, a displacement such as shown in Figures 1 and 2 is positioned in the mold at each place where a cutting
10 element is to be mounted. Each mounting pad thus formed in the bit body will have a relief groove such as shown in Figure 3. An example of a PDC cutter drill bit made according to the invention is shown in Figure 4. The bit body 100 has thereon a plurality of blades 110. Each of the blades 110 has mounted thereon on
15 mounting pads (shaped according to Figure 3) a PDC cutting element 112. Each PDC cutting element 112 includes a diamond table 113 affixed to a tungsten carbide substrate 114. The bit body 100 includes suitably positioned nozzles or "jets" 120 to discharge drilling fluid in selected directions and at selected rates of flow.

The foregoing embodiments of the invention are directed to bit bodies
20 being formed by infiltrating powdered tungsten carbide with a binder alloy in a suitable mold. In other embodiments of the invention, a bit body such as shown at 100 in Figure 4 can be made from steel or other alloy which can be machined or otherwise cut and finished formed using conventional machining and/or grinding equipment. In this embodiment, a bit body "blank" is rough formed such as by
25 casting or forging, and is finished machined to include at least one of the blades 110 having mounting pads for cutting elements. In this embodiment, and referring again to Figure 3, the mounting pads 25 are formed by grinding or machining to

include a relief groove 26. In embodiments of the invention which have a bit body that is finish machined from a bit body blank, the relief grooves 26 may have any suitable width, but preferably have about the same width as in the previous embodiments including the infiltration-molded bit body.

5 A drill bit made according to the invention can have reduced breakage of diamond tables on the cutting elements as compared with prior art drill bits made without such relief grooves. Such bits may provide increased bit life and reduced drilling costs.

10 While the invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

- 1 1. A method for forming a drill bit body, comprising:
2 infiltrating powdered tungsten carbide with a binder alloy in a mold, the
3 mold having therein at least one displacement adapted to form a mounting pad for
4 a cutting element, the displacement comprising a substantially cylindrical body
5 having a diameter selected to substantially conform to a radius of the cutting
6 element and a projection adapted to form a relief groove under a position of a
7 diamond table in the cutting element when the cutting element is mounted on the
8 pad, a width of the relief groove selected so that the relief groove extends back
9 from an outer surface of the bit body at least about 40 percent of that portion of a
10 thickness of the diamond table which does not extend past the outer surface.
- 1 2. The method as defined in claim 1 wherein the cutting element comprises a
2 tungsten carbide substrate, the substrate brazed to the mounting pad.
- 1 3. The method as defined in claim 1 wherein the at least one displacement
2 comprises a castable material formed into a single body.
- 1 4. The method as defined in claim 1 wherein the projection extends past an
2 external surface of the displacement by about 0.025inches.

1 5. A drill bit body comprising:
2 a main body having at least one blade formed therein; and
3 at least one cutting element mounting pad formed on the at least one blade,
4 the mounting pad adapted to receive therein a substrate of a cutting element, the
5 mounting pad having a relief groove therein under a position of a diamond table in
6 the cutting element when the cutting element is mounted on the pad, a width of the
7 relief groove selected so that the relief groove extends back from an outer surface
8 of the blade at least about 40 percent of that portion of a thickness of the diamond
9 table which does not extend past the outer surface.

1 6. The drill bit body as defined in claim 5, wherein the bit body is formed
2 from powdered tungsten carbide infiltrated by a binder alloy.

1 7. The drill bit body as defined in claim 5 wherein the relief groove has a
2 depth of 0.025 inches.

1 8. A drill bit comprising:
2 a bit body having a plurality of blades formed therein; and
3 a plurality of cutting elements mounted on each of the blades, each cutting
4 element mounted on a cutting element mounting pad formed on one of the blades,
5 the mounting pad adapted to receive therein a substrate of the cutting element, the
6 mounting pad having a relief groove therein under a position of a diamond table in
7 the cutting element when the cutting element is mounted on the pad, a width of the
8 relief groove selected so that the relief groove extends back from an outer surface
9 of the blade at least about 40 percent of that portion of a thickness of the diamond
10 table which does not extend past the outer surface.

1 9. The drill bit as defined in claim 8 wherein the bit body comprises powdered
2 tungsten carbide infiltrated with a binder alloy.

1 10. The drill bit as defined in claim 8 wherein each of the relief grooves has a
2 depth of about 0.025 inches.

1 11. A drill bit body comprising:
2 a main body having at least one blade formed therein; and
3 at least one cutting element mounting pad formed on the at least one blade,
4 the mounting pad adapted to receive therein a substrate of a cutting element, the
5 mounting pad having a relief groove therein under a position of a diamond table in
6 the cutting element when the cutting element is mounted on the pad, the drill bit
7 body formed by machining a bit body blank.

1 12. A method for forming a drill bit body, comprising:
2 infiltrating powdered tungsten carbide with a binder alloy in a mold, the
3 mold having therein at least one displacement adapted to form a mounting pad for
4 a cutting element, the displacement being made from a single component
5 comprising a substantially cylindrical body having a diameter selected to
6 substantially conform to a radius of the cutting element and a projection adapted to
7 form a relief groove under a position of a diamond table in the cutting element
8 when the cutting element is mounted on the pad.

1 13. The method as defined in claim 12 wherein the relief groove has a depth of
2 about 0.025 inches.

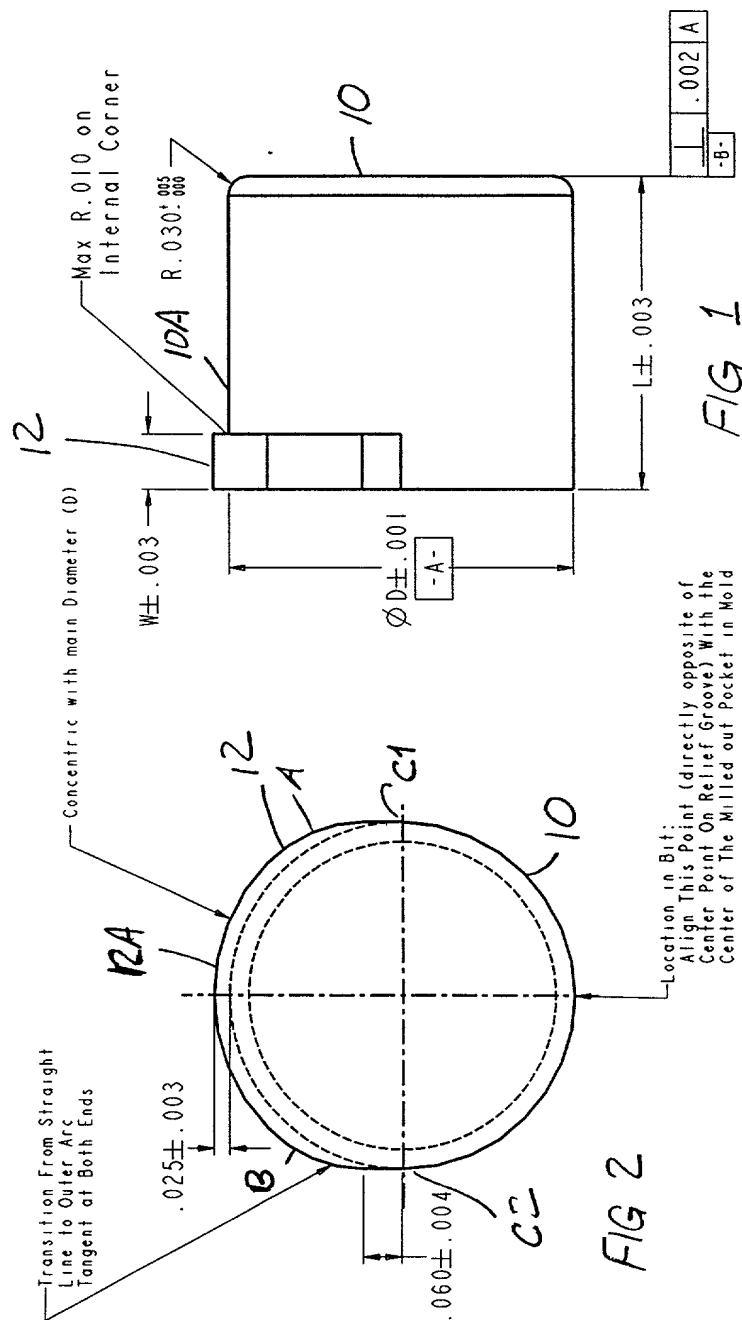
- 1 14. The method as defined in claim 12 wherein the relief groove extends back
2 from an outer surface of the blade at least about 40 percent of that portion of a
3 thickness of the diamond table which does not extend past the outer surface.

STRUCTURE FOR POLYCRYSTALLINE DIAMOND INSERT DRILL BIT BODY AND METHOD FOR MAKING

ABSTRACT

A method for forming a drill bit body is disclosed which comprises infiltrating powdered tungsten carbide with a binder alloy in a mold. The mold has therein at least one displacement adapted to form a mounting pad for a cutting
5 element. The displacement comprises a substantially cylindrical body having a diameter selected to substantially conform to a radius of the cutting element and a projection adapted to form a relief groove under a position of a diamond table in
the cutting element when the cutting element is mounted on the pad. The width of
the relief groove is selected so that the relief groove extends back from an outer
10 surface of the bit body at least about 40 percent of that portion of a thickness of
the diamond table which does not extend past the outer surface.

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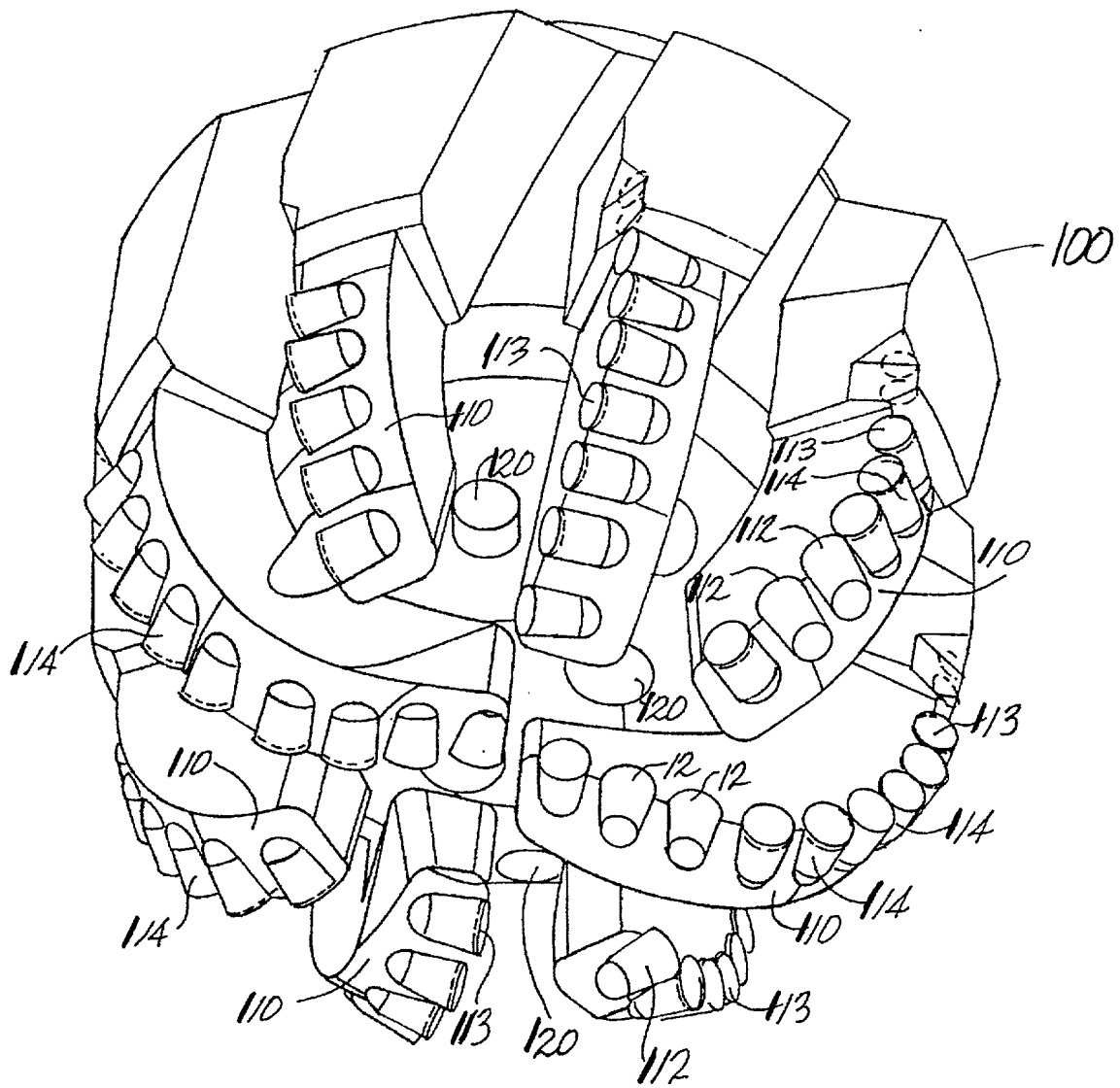


FIG 4

Docket No.

05516/084001

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

STRUCTURE FOR POLYCRYSTALLINE DIAMOND INSERT DRILL BIT BODY AND METHOD FOR MAKING

the specification of which



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(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International

Application Number _____

and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

(Number)

(Country)

(Day/Month/Year Filed)



(Number)

(Country)

(Day/Month/Year Filed)



(Number)

(Country)

(Day/Month/Year Filed)



I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Full name of fourth inventor, if any	
Fourth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of fifth inventor, if any	
Fifth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	

Full name of sixth inventor, if any	
Sixth inventor's signature	Date
Residence	
Citizenship	
Post Office Address	